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ENERGY USE ENGINEERING DEPARTMENT

PROJECT #8412

ENERGY CONSUMPTION

FOR

AN ELECTRIC GOLF CAR

ENERGY MANAGEMENT DIVISION

B.C. Hydro

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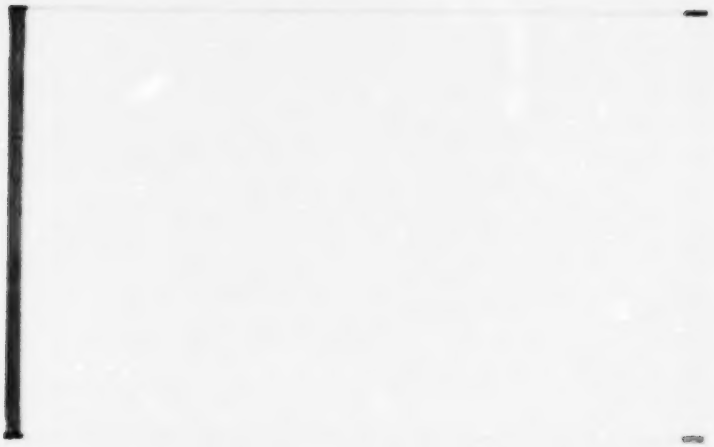

ENERGY USE SERVICES

The Energy Use Engineering Department provides engineering, technical and marketing utilization-point information required for business planning, energy conservation, energy management, marketing and customer service activities.

Information includes electric and gas load characteristics, efficiencies, operating costs, performance and economies; usage trends, trade and industry practice, equipment availability and developing business opportunities; codes and standards; the potential impacts of energy management, alternative services and marketing activities; and customer needs, alternatives and preferences.

The service is provide by a team supervised as follows:

***HEATING, AIR CONDITIONING, VENTILATION & REFRIGERATION TECHNOLOGIES**	**Dr. Z. El-Ramly, P.Eng.**	(663-3277)
***ELECTRICAL AND GAS TECHNOLOGIES AND ELECTRIC & GAS INDUSTRIAL APPLICATIONS** (including associated total-energy, district and waste energy applications; electric and gas vehicles, power factor and demand control)	**G.D.A. Henriques, P.Eng.**	(663-3286)
***RESIDENTIAL AND COMMERCIAL APPLICATONS CUSTOMER-OWNED ALTERNATE ENERGY SYSTEMS TECHNOLOGIES** (including associated appliances, lighting, wiring, water heating, electric and gas vehicles, solar, small hydro, wind, wood, and biomass)	**R.F. Hughes, P.Eng.**	(663-3288)

Please don't hesitate to contact us should you require additional information or should you have any suggestions on how we can better provide the service required.

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PROJECT #8412

ENERGY CONSUMPTION

FOR

AN ELECTRIC GOLF CAR

SUMMARY

An electric golf car was monitored for a two-week period to obtain electric consumption figures for customer information. Typical golf car utilization is 18 holes per game (approximately 6,500 yards), two games per day, and 250 days per year. Based on this utilization and the monitored data, an electric golf car consumes 1,548 kilowatt-hours per year.

In comparison to gasoline powered golf cars, electric vehicles are cleaner, quieter and more efficient to operate which can result in a $60 annual operating cost saving.

PROJECT:

Initiated/Requested by:	R.F. Hughes
Date Completed:	October 1984
Completed by:	B.K. Lowe
Supervised by:	R.F. Hughes
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ENERGY USE ENGINEERING DEPARTMENT

PROJECT SUMMARY

PROJECT NO. 8412 PRIORITY 3

TITLE: ENERGY CONSUMPTION FOR AN ELECTRIC GOLF CAR

INITIATED/REQUESTED BY: R.F. HUGHES

ASSIGNED TO: B.K. LOWE ASSIGNED BY: R.F. HUGHES

DATE ASSIGNED: AUGUST 1984 DATE REQUIRED:

ESTIMATED COMPLETION: OCTOBER 1984 COMPLETED: OCTOBER 1984

OBJECTIVES AND NOTES:

In response to a number of customer inquiries on the operating costs of electric golf cars:

1. Determine the energy consumption of an electric golf car and
2. Compare its operating cost to electric vs. gasoline power.

COPIES TO: DEPARTMENT MANAGER (THEN RECORD FILE), BLUE FILE, SUPERVISOR, (R.F. HUGHES)
R.M. Van Schilt

PLEASE ADVISE AS SOON AS POSSIBLE IF CHANGES ARE REQUIRED ABOVE

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1.0 INTRODUCTION

Motorized golf cars are common vehicles on most major golf courses. Since EUE had no data on actual consumption for these vehicles and as a result of a recent inquiry, this report was initiated to determine the annual electrical operating costs of an electric golf car. An operating cost comparison to a gas powered golf car is also given.

1.1 Assumptions

The annual electricity consumption is a function of the length of the trip and the number of trips per year.

Conversations with the Golf Car Centre and other golf clubs, revealed that the distance travelled depends on the driver, the number of holes played and the golf course layout. Clubs in the Lower Mainland are fairly compact and generally cover 6,300 to 6,500 yards for 18 holes. This report assumes that the car travels 6,500 yards for each 18-hole trip. Different drivers should not affect electrical usage too much unless the driver wanders off course quite often.

A golf car is usually sent out two or three trips each day and is recharged during the night. Two trips per day is assumed in this report.

The length of the playing season is governed by the weather; the Golf Car Centre indicated that a typical season is 250 days per year for the Vancouver area.

1.2 Method of Investigation

The results in this report are based on information supplied by the Golf Car Centre in Surrey, and monitored data of a golf car at the Capilano Golf Club. Only one golf car is monitored

because of the difficulties in trying to keep track of the trips taken by the cars without interferring too much with the golf club's normal operation.

2.0 EQUIPMENT

One B. C. Hydro kilowatt hour meter - Westinghouse Type D3S, Serial #2572315. Read to ±.5 kW.h.

One battery charger - Lestronic II, Model 7850, primary rating 115V, 60 Hz, 12.5 Amp. Output maximum 36VDC-25A.

One Yamaha golf car - two passengers, car #5. See attached pamphlet for specification.

3.0 PROCEDURES

A hydro kilowatt hour (kW.h) meter was installed between the wall socket and the charging system (Figure 1). The meter measured the energy used by the #5 car and its charger. Personnel from the Capilano Golf Club recorded the daily meter reading and the daily number of holes played using car #5. The vehicle charger system was monitored continuously for fourteen days from 10 August to 24 August 1984.

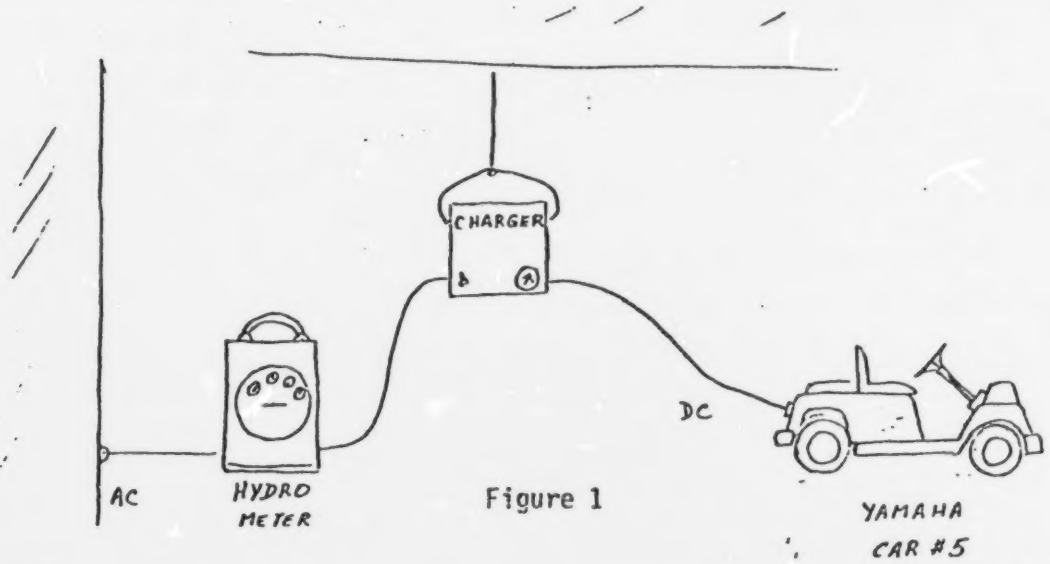

Figure 1

4.0 DATA ANALYSIS

4.1 Monitored Data

The data in Table 1, Column A and B was recorded by golf club personnel with the exception of the first and last meter reading, which were recorded by the writer.

Column C, watt-hours used per hole (Wh/hole), is obtained by subtracting daily (i th) reading from Column A (in kilowatt-hour) and dividing by the daily reading from Column B.

$$C_i \text{ Wh/hole} = \frac{(A_{i-1} - A_i)\ 1{,}000}{B_i} \qquad \text{for the i th day}$$

The inconsistency of data is modified and explained in Appendix I.

TABLE 1

ACTUAL GOLF CAR PERFORMANCE

Day (i) (10 Aug 84)	A Meter Reading	B # of Holes	C Wh/ Hole
1	1,426	36	166.67
2	1,432	18	166.67
3	1,435	36	166.67
4	1,441	13	230.77
5	1,444	18	222.22
6	1,448	36	166.67
7	1,454	18	166.67
8	1,457	18	166.67
9	1,460	18	333.33
10	1,466	36	250.00
11	1,475	18	166.67
12	1,478	36	83.33
13	1,481	36	83.33
14	1,484	36	194.44
15	1,491		

Column C is presented in another format on Table 2 according to the frequency of occurrence. The 167 Wh/hole consumption, which occurred most frequently, could indicate that this is a more accurate figure. Closer analysis (Section 4.2) showed energy used was 171.96 Wh/hole.

TABLE 2

Value Whrs	Frequency of Occurrence
83	2
167	7
194	1
222	1
231	1
250	1
333	1

4.2 Average Consumption Per Hole

Using the revised data in Table 3, the average consumption per hole can be determined by dividing the difference between the first and last meter reading by the total holes played.

$$\text{Average consumption} = \frac{(A_{15} - A_1)}{\sum_{i=1}^{14} B_i} \times 1{,}000$$

$$= \frac{65 \text{ kW.h}}{378 \text{ holes}} \times 1{,}000$$

$$= 171.96 \text{ Wh/hole}$$

TABLE 3

REVISED GOLF CAR PERFORMANCE

Day (i)	A Meter Reading	B # of Holes	C Wh/ Hole
1	1,426	36	166.67
2	1,432	18	166.67
3	1,435	36	166.67
4	1,441	18	166.67
5	1,444	18	222.22
6	1,448	36	166.67
7	1,454	18	166.67
8	1,457	18	166.67
9	1,460	36	166.67
10	1,466	54	166.67
11	1,475	18	166.67
12	1,478	18	166.67
13	1,481	18	166.67
14	1,484	36	194.44
15	1,491		

* See Appendix I for details.

4.3 Annual Consumption

The annual consumption is calculated using Average Consumption[3] and the assumptions in Section 1.1.

$$\text{Annual Consumption} = (\text{kW.h/hole}) \times (\text{\# of holes/day}) \times (\text{\# of days/year})$$

$$= \frac{(171.96)}{1{,}000} \times (36) \times (250)$$

$$= 1{,}547.64 \text{ kWhrs}$$

Current electric cost is about 5¢/kW.h, therefore the annual electric cost is:

$$1{,}547.64 \times \$0.05 = \$77/\text{year}.$$

4.4 Comparison to Gas Powered Golf Cars

The characteristic of gas powered golf cars, presented in Table 4, is determined from information supplied by the Golf Car Centre and various golf clubs. Electric vehicles

definitely have many advantages over gas powered vehicles and are the preferred choice in enquisite clubs. The lacking factor in electric vehicles is that it requires a longer fuel replacement period.

TABLE 4

	Electric	Gas
Operation	electric-step speed	self-starting accelerator
Environment	quiet, clean	higher noise and minor fume
Maintenance	battery replacement $600/3 years	service $30/year
Fuel	overnight recharge 3.1 kW.h/18 hole	fast recharge 1 - 1.5 litres/18 hole

Using our assumed utilization in Section 1.1, the annual operating cost (includes maintenance) of electric vehicle is $60 less than that of gas vehicle. The saving is due to the lower cost of electric fuel, therefore the higher the utilization, the higher the saving will be.

TABLE 5

Vehicle	Annual Operating Cost
Gas	$336 @ 49¢/litre
Electric	$277 @ 5¢/kW.h

A typical golf club would trade in the vehicles after about five years of use. The total cost of ownership (ignoring inflation and fuel escalation) is $3,945 for electric and $4,320 for gasoline powered golf cars.

TABLE 6

COST OF OWNERSHIP

	Electric	Gas
Capital Cost	$4,560	$4,640 (2-stroke engine)
Operating Expense/year		
Fuel	$ 77 @5¢/kW.h	$ 306 @49¢/litre
Maintenance	$ 200	$ 30
Trade-in Value at end of 5 years	-2,000	-2,000
Total Cost Over 5 Years	$3,945	$4,320
Average Cost/Year	$ 789	$ 864

5.0 CONCLUSION

Energy use for golf car varies with the design and age of the car, charging equipment as well as the length of use. Monitored data on a Yamaha electric golf car indicated that if it is used for two 18-hole games per day and 250 days a year, the annual energy cost is about $77 (@ 5¢/kW.h).

TABLE 7

Energy Consumption for a Yamaha Two-Passenger Golf Car

	Energy	Cost
Energy use per hole	172 Whrs	$0.0086
Energy use per year	1,548 kWhrs	$77

@ 5¢/kW.h

Compared to gas vehicles, electric golf car is cleaner and quieter, but its refueling time is longer. Operating cost becomes increasingly cost effective for electric vehicles as the utilization increases. Based on our assumed utilization, electric vehicles can result in a $60 annual saving over gas vehicles.

6.0 RECOMMENDATION

The data provided in this report is obtained from one vehicle. Although the consumption is a typical figure for this vehicle and cannot be generalized into a typical figure for all two-passenger golf cars, it does provide some indication of the expected consumption. If there is an increase in interest on golf car consumption, then further monitoring of additional vehicles is recommended.

APPENDIX I

Calculation

APPENDIX I - Average Consumption Per Hole - Calculation

Three methods were used to determine average consumption. Of these methods, Method 3 is considered to be most accurate.

(a) Method 1 - Average consumption per hole is determined by averaging the consumption per hole for each day.

$$\text{Average consumption}^1 = \frac{\sum_{i=1}^{14} C_i}{14}$$

$$= 181.15 \text{ Wh/hole}$$

This method is subject to rounding error on meter reading as well as recording error on the number of holes played. This is the least accurate method unless a substantially large number of data is collected.

(b) Method 2 - Average consumption per hole is obtained by dividing the total energy used by the number of holes played during the fourteen days.

$$\text{Average consumption}^2 = \frac{A_{15} - A_1}{\sum_{i=1}^{14} B_i} \times 1{,}000$$

$$= \frac{65 \text{ kW.h}}{373 \text{ holes}} \times 1{,}000$$

$$= 174.26 \text{ Wh/hole}$$

This method reduces reading error for the kilowatt hour meter but does not account for recording errors.

(c) Method 3 - Average consumption is determined by rejection and modification of data before applying Method 2. Great care was used to prevent biased alteration of data. The guidelines used were:

(i) the first and last meter readings were carefully checked several times to ensure it was correctly recorded. The other meter reading cannot be corrected and is assumed to be subject to rounding error only;

(ii) since golf is played by the number of holes, the energy used should be in quantum units or close to it;

(iii) the frequent occurrence of the figure 166.67 Wh/hole indicates that this could be the quantum unit;

(iv) 18 holes per game or trip is most common and each day should have a multiple of 18 holes.

Table 3 is the modified version of Table 1 using the above guideline. Alteration is limited to Column 3 and the reasons for the changes are listed following Table 3.

Using the revised data in Table 3, the average consumption is calculated as in Method 2:

$$\text{Average consumption}^3 = \frac{A_{15} - A_1}{\sum_{i=1}^{14} B_i}$$

$$= \frac{65 \text{ kW.h}}{378 \text{ holes}} \times 1{,}000$$

$$= 171.96 \text{ Wh/hole}$$

TABLE 3

Day (i)	A Meter Reading	B # of Holes	C Wh/ Hole
1	1,426	36	166.67
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11	1,475	18	166.67
12	1,478	18	166.67
13	1,481	18	166.67
14	1,484	36	194.44
15	1,491		

Reasons for Change

Day 4 - 13 holes/game is uncommon. If 18 holes per game is used, then the quantum figure 166.67 Wh/hole is obtained.

Day 5 - No change here because 222.22 Wh/hole is within the rounding and reading error, i.e. (1,448 - 1,444 - 1) ÷ 18 x 1,000 = 166.67 Wh/hole.

Day 9 - If the number of holes were 36 (one trip more) then the energy used per hole would be our quantum number, i.e. (1,466 - 1,460) ÷ 36 x 1,000 = 166.67 Wh/hole.

Day 10 - If the number of holes were 54 (one trip more) then the quantum level is obtained, i.e. (1,475 - 1,466) ÷ 56 x 1,000 = 166.67 Wh/hole.

Day 12 - If only 18 holes were played (recorded one trip extra) then the quantum value is reached.

Day 13 - Same as Day 12.

Day 14 - The error is within the rounding and reading error. See Day 5.

TABLE 4

Energy Consumption Per Hole

	Wh/hole
Method 1	181.15
Method 2	174.26
Method 3	171.96

OPERATING COST CALCULATION

Gas Powered Car

Fuel Consumption: 1.25 liter/second x 2 rounds/day x
250 days/year x 49¢/liter = $306/year

Maintenance = $30/year

Operating Cost = $336/year

Electric Car

Fuel Consumption: (3.096 kW.h/round) x (2 rounds/day) x
(250 days/year) x ($.05/kW.h) = $77/year

Maintenance - battery replacement $200/year

Operating Cost = $277/year